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A good farmer pays attention to the weather

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ABSTRACT

A key message of the 2014 US 3rd National Climate Assessment report is that climate change poses threats to agriculture and will require adaptation and mitigation by farmers. In the upper Midwest, the increase in total precipitation and a 37% increase in very heavy precipitation over the past 40 years are expected to continue and affect the productivity of corn-based cropping systems. The current situation and weather projections suggest that in the future, significant degradation of soil and water resources can be expected. While a number of adaptive management strategies have potential to address soil erosion, poor water quality, and production losses, farmer responses to a changing climate are not well understood. The research presented here examines how farmers' self-identity as "a good farmer" can translate into specific incremental and transformative adaptations of farming strategies. Analysis of a 2012 survey of 4778 upper Midwest farmers finds that three nodes in the identity control model, the biophysical situation, reflected appraisals comprised of a set of beliefs which are sources of information input, and a farmer's identities, influence variations in selected adaptive management practices. The biophysical situation (flooding, drought, saturated soils, and/or having a river run through the farm) are significant explanatory variables in seven of the eight models and farmer's identities, conservationist and/or productivist, are significant in all models. This is evidence that farmers are paying attention to the biophysical situation as well as being guided by their own understandings of themselves as good farmers in making decisions about their farm operation. More research is needed to better understand what activates identities, core values and beliefs and how some values are privileged over others in adaptive decisions. This work suggests that educators and policymakers should focus on interventions, incentives and policies that activate the farmer's conservationist identity to increase adaptations that protect the agroecosystem in the longer term.

1. Introduction

The natural variability of local weather conditions from day to day and year to year can be a barrier to farmers' understanding of climate change and the extent to which they perceive adaptive management is needed (Wilke and Morton, 2015). Adaptive management in agriculture can entail minor adjustments in practices to major changes to the farm operation. How farmers give meaning to changing weather and climate and construct intentions to adapt (or not) are situated within the detailed context of personal observations and experiences on their own lands (Arbuckle et al., 2014, 2015;

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Morton et al., 2015). Although farmers can be rational agents who ''behave strategically and tactically in relation to their farming practices," there is significant evidence that scientific climate knowledge is filtered through local knowledge constructed from everyday encounters with weather and the land both felt and observed (Geoghegan and Leyson, 2012, p. 59). This filter is based in personal values and beliefs that define a situation, elicit goals, and guide actions (Verplanken and Holland, 2002). The underlying central values and beliefs a person holds shapes their self-concept and contributes to their sense of identity that, in turn, influences behaviors (Verplanken and Holland, 2002; Burton, 2004; McGuire et al., 2012, 2015).

Research on Midwestern corn-soybean farmers reveals substantial variations among farmers in beliefs about climate change, experience with weather hazards, perceptions of weather and climate risks to their operation, and levels of confidence or sense of efficacy they have in their capacity to address changing conditions (Arbuckle et al., 2014). These variations are associated with whether they support taking actions to adjust and prepare for increased precipitation, more frequent drought and increased weather variability in general (Arbuckle et al., 2014, 2015). What is not well understood is how farmers' values and beliefs and identities are integrated in ways that have potential to lead to adaptive management and why some adaptations chosen are incremental adjustments and others lead to transformative adaptations. Emerging work on farmer identities (McGuire et al., 2012, 2015; Hyland et al., 2016; Zhang et al., 2016) derived from well-established person and role identity literatures (Stets, 2006; Burke and Stets, 2009; Stryker, 1980) offer a useful theoretical model for exploring how different biophysical weather and climatic situations, in addition to farmers' identities can influence farmers' response to biophysical events.

In this paper, our interest is in understanding how different biophysical situations in addition to values and beliefs that are core to farmer identities influence the adaptive actions that are taken. First, the farmer identity control model and the feedback processes that maintain or change the salient identity are presented. Next, the biophysical situation node in the model is elaborated around climatic and weather phenomenon with attention to press and pulse variations in the agroecosystem that these phenomena generate. Then several different biophysical situations are examined using data from a 2012 survey of 4778 farmers on their beliefs and perspectives on agriculture and weather variability in the United States (US) upper Midwest aka the Corn Belt (Arbuckle et al., 2013). A description of the methods for gathering and analyzing the data are followed by results and a discussion about the farmer identity model and implications for adaptations to climate change.

2. Farmer identities and the biophysical situation

2.1. The identity control model

Values are a latent means of evaluating the world around us and used to privilege certain actions or outcomes (Corner et al., 2014). Values are defined as enduring concepts or beliefs about desirable end states or behaviors that transcend specific situations and are used to evaluate behaviors and events, and are ordered by relative importance (Wolf et al., 2013). Values and beliefs influence perceptions and interpretations of situations and when activated lead to privileging certain actions over others (Rohan, 2000; Wolf et al., 2013; Corner et al., 2014). They need to be activated to affect information processing and behavior according to Verplanken and Holland (2002). Further, the priming of a value only affects information processing, choices and behavior if that value and associated beliefs are central or core to the self-identity. Burton's (2004) original work with Great Britain farmers constructed typologies of productivist and conservationist farmer identities and has been used and extended by other researchers to better understand how identities influence farmer's management decisions (McGuire et al., 2012, 2015; Hyland et al., 2016; Zhang et al., 2016). Value and belief activation and identity activation occur simultaneously and become visible in behaviors or actions taken (Verplanken and Holland, 2002).

Central meanings that farmer's with a productivist identity entail are the efficient production of high grain yields on large tracts of land. Efficient production values are evidenced by use of chemical technologies, up-to-date equipment that can quickly plant and harvest crops, and goals for high yield and profits per acre. The emphasis on annual yields and profits reflect values and beliefs that give priority to short-term productivity over long term land management. Meanings for being a good farmer from a conservationist perspective incorporate underlying values and beliefs that encompass more than land as a tool to create income and extend beyond annual productivity. In contrast, the conservationist's underlying values and beliefs include longer term goals of conserving and improving the land resources. Conservationist core values and beliefs (and the identities where these are embedded) are evidenced by concern for nutrient run-off, soil erosion, and prioritization of ecological impacts over high yields.

The basic identity control model (Fig. 1) is a continuous feedback loop connecting four nodes (comparator, output, social and biophysical situation, and input) that operates as a system that is constantly checking to see if a person's actions (outputs) are producing the desired effect (Burke, 1991). When a person acts in a particular social or biophysical situation (outputs), reflected appraisals provide feedback about the social biophysical situation (inputs). Through a comparative process, the inputs (meanings in the situation that have been changed by the behavioral outputs) are compared with current identity standards (the meanings tied to how the individual views him/herself as a farmer) to verify the identity (McGuire et al., 2012). No changes in behavior or actions (output) are needed when the identity is verified. However, if the feedback (input) from the situation are inconsistent with the identity standard, the individual reassesses his/her actions (outputs) to change

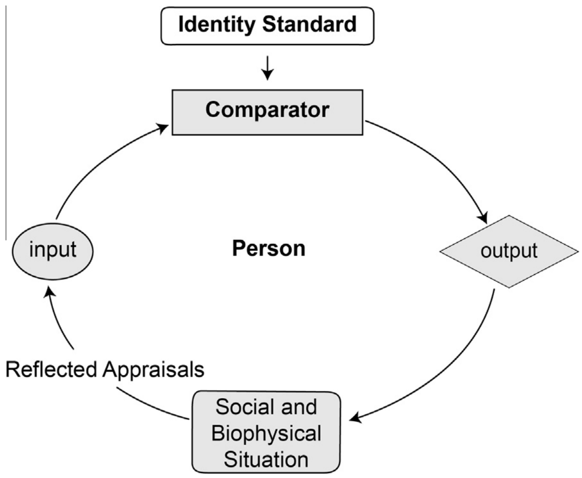

Fig. 1. The basic identity control model is a continuous feedback loop connecting four nodes (comparator, output, social and biophysical situation, and input) which operate as a system that is constantly checking to see if a person's actions (outputs) are producing the desired effect. Adapted from Burke (1991).

the situational meanings to be consistent with the identity standard or alters their identity standard to become consistent with the situational inputs (Burke and Stets, 2009; Burke, 1991; McGuire et al., 2012).

An individual has various identities that are relevant across different roles and situations, and are arranged in a hierarchy based on which identity is most salient in a particular situation. A farmer has a role identity that follows this basic pattern (Fig. 2). This role identity includes all the meanings a farmer attaches to the self while performing that role (Stets, 2006; McGuire et al., 2012). The principle-level identity standard, "I am a good farmer" is interconnected to other lower level program identities that are used to verify this overarching "good farmer" identity the farmer has attached to the self. Each

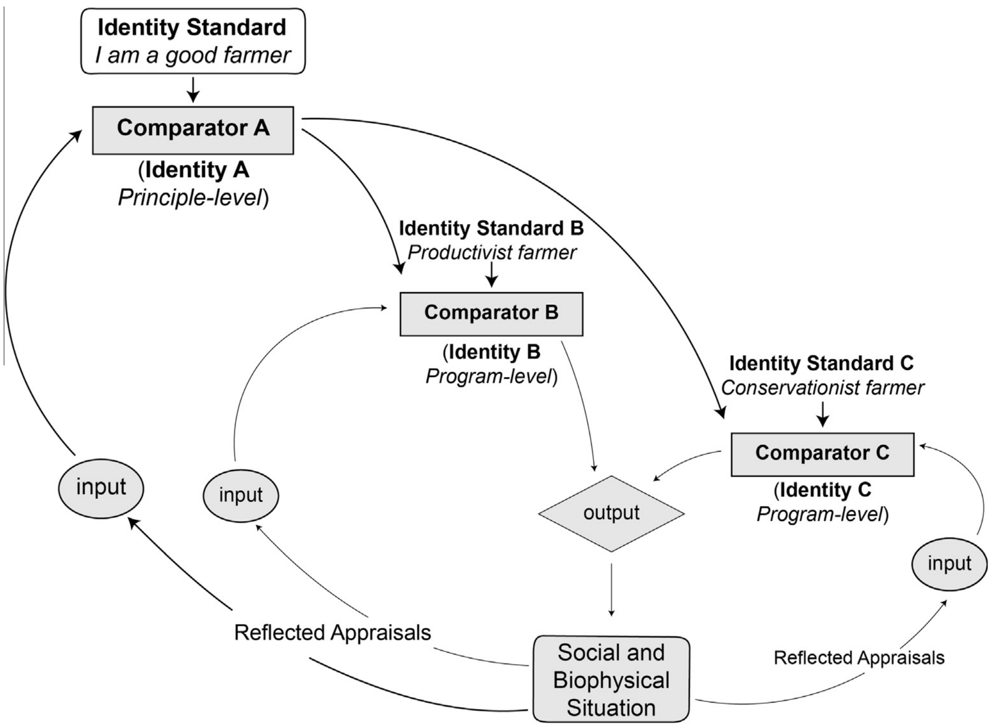

Fig. 2. The four basic nodes (social and biophysical situation, input, identity standard, and output) of the identity control model have recursive dynamics which occur simultaneously across lower level identities to maintain or modify the overarching principle-level "good farmer" identity. Adapted from McGuire, J., Morton, L.W., Cast, A. 2013. Reconstructing the Good Farmer Identity: Changing Attitudes and Behaviors through Environmental Performance-based Management. Agriculture & Human Values, June 20 published online 30 (1), 57–69.

identity and the feedback loops within the hierarchy have multiple input meanings (and core values and beliefs which define those meanings) which are compared to the identity standard and (ideally) simultaneously verified when activated (McGuire et al., 2012). When the farmer identity is activated, each output action the farmer performs is in support of one or more of his or her farmer identities. Fig. 2 illustrates two of a farmer's lower level program identities, productivist and conservationist, that when exposed to a situations are used by the farmer to verify his or her overarching "I am a good farmer" identity.

2.2. The biophysical situation

McGuire et al. (2015) tested five social-ecological policy situations entailing nuanced variations associated with soil, water and wildlife conservation. They found that each situation activated different combinations of four farmer identities: the productivist, conservationist, civic minded, and naturalist. Zhang et al. (2016) in their study of the right timing of in-field nutrient practices (e.g. fertilizer applications) to reduce phosphorus loadings in the Maumee River watershed into Lake Erie found that activation of the farmer conservationist identity versus the productivist increased the likelihood of adoption of three known best practices for nutrient management. These studies suggest that within the good farmer identity model, the biophysical situation could also be a key to activating adaptive management strategies. In this research we frame the biophysical situation as press and pulse processes that change the agroecosystem that a farmer manages. Press processes, natural and human induced, alter the agroecosystem in small sometimes invisible increments; while pulse events transform the agroecosystem suddenly (Collins et al., 2011). Press and pulse dynamics are recursive in that humans adapt to the disturbance in the agroecosystem; and their adaptations influence future presses and pulse events (Morton and Rudel, 2014). This iterative feedback pattern mimics the identity control model.

Increasingly variable global and local climate and weather conditions are drivers of agroecosystem change. For example, over the past sixty years, climate science has documented a slight warming, mostly in the cooler half of the year which has shifted the hardiness zones northward in the upper Midwest of the United States (US), and a 5–10% increase in average yearly precipitation in most upper Midwestern states (Arritt, 2016). However, the biggest change in this region are observations of significant increases in more frequent, heavy rainfall events (over 101.6 mm) and predictions of continuing heavy rainfall into the next three decades (Melillo et al., 2012; Walthall et al., 2012). These weather patterns present Midwestern farmers with steady, sometimes subtle press-like events such as warmer winters and water-laden, saturated soils that alert them to the need to potentially adjust planting dates, change the timing and rates of fertilizer applications (nutrient management), modify other in-field and edge of field management practices, and prepare to address pest and diseases. Heavy rainfall exposes farmland to intense and sudden pulse events that can lead to fast-moving runoff, substantial soil erosion and potential off-farm nutrient flows as well as extensive flooding and crop losses.

2.2.1. Biophysical events

Adaptation in response to climate change varies by geography, cropping systems, topography and soils, and local experience with climate and weather (Melillo et al., 2012; Walthall et al., 2012; Morton et al., 2015). Haigh et al. (2015) find that current weather is more likely to influence certain types of decision making compared to long term climate outlooks. The presses and pulses of the agroecosystem are affected by variability in climate and weather, both locally and globally at different time scales. Farmer adaptive responses to changes in climate and weather can vary from making no changes in the farm operation to incremental adjustments to transformations in land uses and the farm enterprise.

Adaptive responses are defined as adjustments in natural or human systems in response to actual or expected climate stimuli or their subsequent effects, which moderate harm or exploit beneficial opportunities (McCarthy et al., 2001). These adjustments often hinge on whether the impacts are apparent or visible and whether human action is perceived as being able to moderate harm or alleviate impacts. Presses, the steady pressures and subtle changes that occur are sometimes visible and evident to observant humans and sometimes not. Incremental soil erosion, saturated soils that delay planting, or insect and disease pressure from days of high humidity and warmth are press-like with accumulated impacts that may only be apparent when compared to a historical baseline or when they reach a threshold over time that make them visible (Morton and Rudel, 2014). In contrast, pulses are highly visible and disrupt the agroecosystem in sudden ways such as flooding and the formation of deep gullies and massive sediment loads transported by a heavy rain event (Olson and Morton, 2012).

2.2.2. Values and beliefs

Values, beliefs, perceptions of self-efficacy and controllability as well as perceptions of risk, knowledge, and experience may also be sources of information to the farmer as they evaluate their choices for farming practice. As such, they may be loosely considered as inputs into the system. Here, because values and beliefs are not the same as an identity we consider them to be a separate set of "inputs" as farmers think about farming practices. Fig. 2 represents the values and beliefs that may alter the different sorts of practices to employ on their farms. Reflected appraisals can include not only perceptions of risk or opportunity from weather and climate conditions but also activated beliefs about climate change causality. Work by Arbuckle et al. (2015) finds that beliefs had significant direct effects on perceived risks from climate change and support for adaptation varied with perceptions of risk. Self-efficacy or confidence that one has the skills or capacities to manage and control the situation can also be another factor that affects how farmers respond to changes in the biophysical environment, influencing to some extent the degree to which they can effectively respond match or incongruence with the farmer's identities. Individual motivation to take certain actions can be limited by low self-efficacy if the farmer perceives himself as unable to act on perceived threats such as those that might come from the biophysical environment (Adger et al., 2009). Beliefs that climate change is caused by natural causes can lead to responses indicating a belief that nothing can be done; a finding consistent with research that finds that outward locus of control is associated with lower support for greenhouse gas mitigation (Arbuckle et al., 2015). Hyland et al. (2016) report that Wales animal farmer identities, productivist and countryside steward, show low levels of awareness of climate change; and differ in their motivations to adopt pro-environmental behavior such as mitigating greenhouse gas (GHG) emissions.

2.2.3. Identities

In addition to the direct effects of biophysical events and values and beliefs, farmers' individually held identities may also have a direct effect on farming practices. This research focuses specifically on two farmer identities: the conservationist and productivist. What meanings farmers hold for themselves as farmers (their farmer identities) should have a direct effect on farming practices, independent of biophysical events and values and beliefs. Depending on the meanings contained in farmers' identities, farmers can view adaptation to climate stimuli as a way to reduce short term vulnerability or to increase and enhance long term resilience to weather variability and climate change (Adger et al., 2009; Wolf et al., 2013). Given the nature of the conservationist farmer identity, for example, we might expect an adaptive approach that includes learning from failure and increasing resilience so as to prevent collapse of the agroecosystem or to reorganize the system for recovery once a pulse event has caused collapse (Adger et al., 2009). In contrast, strategies that the productivist farmer might take include practices that quickly remove excess water from fields, reduce annual yield losses and/or expand his operation to take advantage of opportunities to produce more grain.

In this research we propose that biophysical changes from press and pulse environmental forces have the potential to alter the functioning of agricultural systems. These changes become a feedback signal to farmers to make adjustments. Some adjustments will be small and incremental and others will be transformative, leading to the initiation of major changes on the land and within their own enterprise. Farmer outputs – adaptive management strategies – are expected to vary in response to different biophysical situations. Furthermore different values, beliefs, and risk perceptions (that may be related to farmer's identities may also have a direct influence on the type of farming practices employed. Three general hypotheses are proposed to explore how farmers' values and beliefs, identities, and biophysical situations influence adaptive management on their farm operations:

H1. Farmer's identities influence implementation of specific kinds of adaptive management.

H2. Press-like biophysical conditions increase the implementation of incremental adaptations on the farm operation.

H3. Pulse-like biophysical conditions increase the implementation of transformational adaptations on the farm operation.

3. Materials and methods

Data were collected through a stratified random sample survey of corn-soybean farmers from 11 states across the US upper Midwest (Arbuckle et al., 2013). The sample frame included farm operations with greater than 80 acres of corn production and a minimum of US$100,000 of gross sales in 2007. The sample was stratified by 22 contiguous watersheds and covered substantial portions of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio, South Dakota, and Wisconsin. The survey was mailed in February 2012 to 18,707 eligible farmers using a three-wave mailing process: first a survey was mailed, then a postcard reminder, then a final survey to non-responders. Completed surveys were received from 4778 farmers for an effective response rate of 26%. Statistical tests for non-response bias at the watershed level detected no meaningful differences between respondents and non-respondents, indicating that the sample is representative of the target population. See Arbuckle et al. (2013) for survey methodology details.

Five incremental adaptation and three transformative adaptation logistic regression models are used to evaluate the proposed hypotheses. The dependent variable in each model represents the output node in the identity control theoretical model (farming practices). Independent variables were selected to conceptually represent the other three nodes: press and pulse biophysical situations associated with weather and climate conditions; values and beliefs that provide input information; and two farmer's program level identities, the productivist and conservationist.

3.1. Dependent variable construction and analyses

Dependent variables were constructed in two stages: principal component analysis (PCA) with varimax rotation and transformation of the PCA loadings into binary units of 1 and 0. First PCA was used to develop the incremental and transformative adaptation dependent variables for the models (Tables 1 and 2). Thirteen items from the farmer survey were selected as indicators of incremental adaptive management strategies (Table 1) and seven items were selected as indicators

Table 1
Principal component analysis of incremental models.

Indicators of adaptations	Model 1 Sloping Land	Model 2 Soil Management	Model 3 Grass Buffer	Model 4 Integrated Science Technologies	Model 5 Water Control
Uses grassed waterways	0.439	0.018	**0.406**	0.100	−0.433
Uses contour buffer strips	0.113	0.036	**0.733**	−0.033	−0.056
Uses filter strips of grass/trees next to waterways	−0.081	−0.005	**0.768**	0.185	−0.037
Uses field borders of grass/trees	0.124	0.193	**0.596**	0.056	0.167
Uses terraces	**0.758**	−0.194	0.170	−0.017	0.037
Uses cover crops	−0.017	**0.718**	0.170	0.021	0.036
Uses no-till	**0.637**	0.256	−0.071	0.164	0.067
Uses diversified rotations (includes small grains, forages, other crops)	0.045	**0.808**	0.015	−0.002	0.005
Uses nutrient management (optimizes efficiency of fertilizer use)	0.057	0.197	0.018	**0.722**	−0.046
Uses integrated pest management	0.015	0.019	0.062	**0.752**	0.006
Uses best management practices when using irrigation	−0.103	0.007	−0.058	0.167	**0.768**
Uses control structures to drain and store water	0.297	0.049	0.160	−0.080	**0.627**
Uses precision management practices such as GPS	0.087	−0.233	0.125	**0.626**	0.145

Table 2
Principal component analysis of transformative models.

Indicators of adaptations	Model 6 Land Transformation	Model 7 Livelihood Transformation	Model 8 Expansion Transformation
Uses restored or constructed wetlands	**0.769**	0.034	0.025
Converts whole (or portions) crop fields to grass and trees	**0.775**	0.031	0.029
Intensifying or expanding current enterprises	0.000	0.005	**0.811**
Diversifying into other forms of production/different crops	0.058	0.069	**0.795**
Selling or renting part of land	0.003	**0.692**	0.068
Scale back operations (taking land out production, destocking)	0.127	**0.684**	0.049
Quit farming	−0.043	**0.735**	−0.031

of transformative adaptation (Table 2). Individual survey item responses were coded yes (1) if used on owned or rented land and no (0) if the respondent marked familiar with but not used or not familiar with. PCA of the incremental items yielded five models using eigenvalues over 1.0 to confirm statistical and theoretical cohesiveness. Similar analysis of the transformative items yielded three models.

A binary dependent variable for each model was constructed as follows. Three of the incremental factors were comprised of only two survey items each: sloping landscape (Model 1), soil management (Model 2), and water management (Model 5). If a farmer used one or both of these underlying variables, the factor was coded as 1 and if a farmer used neither practices it was coded as 0. The two remaining incremental factors, grass buffer (Model 3) and science-based production technologies (Model 4) consisted of 4 and 3 underlying variables respectively. Since three of the incremental factors were based on a 0.5 or higher use of the practices within the factor, the same criteria was used for the other two. Thus for the grass buffer factor (Model 3), a farmer had to use at least two of the practices to be coded 1. If the farmer used only 1 or none of the practices, it was coded 0. The science-based technologies factor, (Model 4) comprised of three variables could not cleanly use 0.5 as a break point. For that factor, a farmer had to use 2 or 3 practices to be coded 1; if they used only 1 or 0 of the practices the farmer was assigned a 0.

The livelihood (Model 7) and expansion (Model 8) transformative factors (Table 2) were calculated from the survey question: "Listed below are activities you might do in your farm operation to manage for weather or climate related risks. Please check the boxes that best describe your plans to undertake these activities." A farmer had to indicate they would use the practice as part of a short-term or long-term management strategy to be assigned value of 1. If the respondent was not doing the practice and didn't plan to or not doing, but considering, the response was coded 0. The land transformation factor (Model 6) items were coded the same way as the incremental adaptation items, yes (1) if used on owned or rented land and no (0) if the respondent marked familiar with but not used or not familiar with. Transformative model binary dependent variables were constructed the same as the incremental models: a farmer had to use at least 1 or both variables from the land transformation factor (Model 6) and 2 or more from the livelihood (Model 7) and expansion (Model 8) factors.

3.2. Independent variables

Four survey items were selected to represent the biophysical situation (inputs) (Table 4). Two are pulse situations a respondent could have experienced over the past five years: significant drought on land owned and rented, and significant flooding on any of the land you farm, coded yes (1) or no (0). Two are press situations: a river runs through my land and I experienced saturated soils in the last five years, coded yes (1) or no (0).

Table 3
Principal component analysis of US Corn Belt farmer perceptions of farmer identities[a] (n = 4378).

The good farmer.	Productivist	Conservationist
Has the most up-to-date equipment	0.770	−0.016
Has the highest yields per acre	0.737	0.013
Gets their crops planted first	0.727	−0.052
Has the highest profit per acre	0.692	0.133
Uses the latest seed and chemical technology	0.596	0.333
Cronbach α = 0.76		
Thinks beyond their own farm to the social and ecological health of their watershed	−0.001	0.793
Manages for both profitability and minimization of environmental impact	0.053	0.788
Minimizes nutrient runoff into waterways	0.033	0.787
Minimizes soil erosion	0.046	0.774
Maintains or increases soil organic matter	0.140	0.758
Considers the health of streams that run through or along their land to be their responsibility	−0.029	0.750
Puts long-term conservation of farm resources before short-term profits	0.010	0.729
Minimizes the use of pesticides	0.099	0.615
Manages their farm operation to reduce income volatility	0.305	0.557
Cronbach α = 0.90		

[a] The question was: *People have different opinions about what makes a "good farmer." Please rate the importance of the following items*. Answer options were on a five point scale from *Not at All Important, Not Really Important, Somewhat Important, Important* and *Very Important.*

Table 4
Descriptives.

Variables	N	Range	Mean	Std. Dev.
Dependent adaptations				
Incremental				
Model 1 Sloping Landscape	4778	0–1	0.70	0.46
Model 2 Soil Management	4778	0–1	0.52	0.50
Model 3 Grass Buffer	4778	0–1	0.86	0.35
Model 4 Integrated Science Production	4778	0–1	0.95	0.22
Model 5 Water Management	4778	0–1	0.23	0.42
Transformative				
Model 6 Land Transformation	4778	0–1	0.20	0.40
Model 7 Livelihood Transformation	4778	0–1	0.10	0.29
Model 8 Expansion Transformation	4778	0–1	0.25	0.43
Independent variables				
Biophysical situation				
Experienced drought in the last 5 years	4709	0–1	0.30	0.46
Experienced saturated soils in last 5 years	4701	0–1	0.74	0.44
River runs through land	4592	0–1	0.76	0.43
Experienced flood in last 5 years	4682	0–1	0.37	0.48
Values and beliefs				
Climate change caused by nature	4778	0–1	0.23	0.42
Uncertain climate change is happening	4778	0–1	0.29	0.45
Climate change human or human/nature	4778	0–1	0.39	0.49
Perception of risk scale (factor)	4484	0–1	0.45	0.30
Current practices used on owned land will be effective in future	4177	1–4	2.86	0.73
Current practices used on rented land will be effective in future	3763	1–4	2.82	0.73
Have skills to manage farm in the future	4496	1–5	3.37	0.86
Farmer identities				
Productivist (factor)	4577	1–5	1.73	1.74
Conservationist (factor)	4402	1–10	7.82	2.62
Controls				
Total corn and soy acres	4778	1–13,251	729.42	717.64
Principal operator age in years	4286	22–98	55.38	11.22
Acres of land owned	4778	1–7708	385.37	497.04
Acres of land rented	4778	1–11,119	545.39	718.89

Seven items grouped in three categories represent values and beliefs that provide information into the system: beliefs (climate change is occurring and caused mostly by natural changes in the environment; climate change is occurring and is caused mostly by human activities/or more or less equally natural causes and human activities; and there is not sufficient evidence to know with certainty whether climate change is occurring/it is not occurring); efficacy or confidence in being able to manage in the future (current practices used on owned and rented lands will be effective in the future and I have skills to manage my farm into the future) and; a risk perception scale. This scale was based on farmers' level of concern (not concerned = 1, slightly concerned = 2, concerned = 3 and very concerned = 4) to concern about increased weed pressure, extreme rains, insect pressure, drought, plant disease, heat stress, saturated soils, nutrient loss and soil erosion. The responses were summed to create a score for each farmer (Arbuckle et al., 2014).

The two farmer identities, productivist and conservationist, were constructed using PCA on 16 items from the survey based on McGuire et al. (2012) methodology (Table 3). Analyses revealed distinct underlying values and goals for each identity. A farmer with a strong productivist identity has underlying values of production efficiency and prioritization of seasonal management to meet high yields and profits per acre goals. A farmer with a strong conservationist identity has underlying values that reflect longer-term goals and actions that offer protection of and resilience to soil and water resources and the overall agroecosystem while keeping the land productive and profitable. Varimax rotation with Kaiser Normalization was used in this principal component analysis. The Productivist and Conservationist components produced Cronbach alphas of 0.76 and 0.90 respectively, a KMO of 0.91, and a Bartlett's test of sphericity of 0.000.

Four control variables were included in each model: total corn-soybean acres, principal operator age in years, acres of land owned, and acres of land rented.

4. Results

This random sample of 4778 upper Midwest farmers was 55 years old on average and reported managing on average a total of 729 owned and rented corn and soybean acres (Table 4). Five incremental and three transformative models (eight models in total) are estimated to examine how particular biophysical situations, values and beliefs, and farmer identities directly and independently influence specific kinds of adaptive management. (In doing so, it is recognized that other processes may be occurring; however, our interest is in examining these direct effects.) In particular, this research explores how incremental and transformative adaptations are influenced by press and pulse biophysical conditions (Tables 5 and 6). Three incremental adaptations were used by more than 70% of the farmers in this sample: practices for sloping landscapes (terraces and/or no till) (70%), grass waterways and/or buffers (86%), and integrated science technologies (at least two, precision agriculture such as GPS, IPM, and nutrient reduction strategies) (95%) (Table 4). Almost a quarter of the farmers used water management (controlled drainage or irrigation); and more than 50% used a soil management strategy (cover crops and/or rotations). Transformative adaptations were implemented by a much smaller portion of the sample. Twenty-five percent of the farmers were transforming their operation by expanding, intensifying and/or diversifying into other forms of production or crops. Twenty percent were transforming their farm through changes in land uses by either restoring or constructing wetlands and/or converting fields to grass and trees. A small group (10%) of farmers were making major changes to farming as their livelihood by doing two or more transformative adaptations: selling or renting part of their land, scaling back operations, and/or quitting farming.

Adaptation outputs are examined separately; however, it is important to note that there is no assumption that adaptation outputs are mutually exclusive. Farmers often use a suite of management practices to accomplish multiple goals associated with crop productivity and soil and water agroecosystem impacts (Morton et al., 2015). These outputs are examined independently because it is important to establish that some may be more attractive to some farmers and under certain circumstances. Further, based on prior literature (McGuire et al., 2015), it is assumed that farmers may have both conservationist and productivitist identities that support the principle identity standard, "I am a good farmer"; and social and biophysical situations can activate both identities, only one, or none. Farmers' lands were characterized by having a river run though or adjacent to the land (76%) and self-reported experiences over the last five years (2007–2011) with saturated soils (74%), significant flooding (37%), and significant drought (30%).

Beliefs and values were grouped into conceptual categories: beliefs about climate change causality, perceptions of risk from excess precipitation, confidence in skills, and current practices to continue to be effective into the future (Table 4). More than one-third (39%) of the farmers believed that climate change is mostly or partially caused by human activities; 23% believed that climate change is a natural event, and 29% were uncertain whether climate change is happening. Less than half of farmers (45%) perceived risks to their land from excess water. Confidence that current practices on owned and rented land would maintain the long-term success of their farm operation were quite similar, m = 2.86 and m = 2.82 respectively, representing "confident" on a 1–4 scale. On a five-point scale, farmers were not fully certain or confident (m = 3.37) on average, that they had the knowledge and technical skill to deal with any weather-related threats to the viability of their farm operation.

4.1. Overall findings

In all models, one to three biophysical situations are significantly related to farming adaptations (Tables 5 and 6). The general thesis that the biophysical situation is an important influence in selection of adaptation practices is supported. The evidence suggests that both press and pulse biophysical situations can lead to different incremental adaptations, with some events having slightly stronger effects than others. Two transformational adaptations, model 7 (livelihood) and model 8 (expansion) are significantly influenced by drought and/or flooding pulse events and not having saturated soils. Experience

Table 5
Incremental adaptations.

	Sloping Land Management Model 1				Soil Management Model 2				Grass Waterways & Buffers Model 3			
	B	Wald	Sig.	Exp (B)	B	Wald	Sig.	Exp (B)	B	Wald	Sig.	Exp (B)
Biophysical situation												
Experienced drought in last 5 years	0.25	5.93	0.02	1.28	0.30	10.74	0.00	1.35	0.20	1.77	0.18	1.22
Experienced saturated soils in last 5 years	−0.40	11.85	0.00	0.67	−0.23	5.09	0.02	0.79	0.28	3.88	0.05	1.33
River runs through land	0.50	20.76	0.00	1.64	0.06	0.31	0.58	1.06	1.09	61.73	0.00	2.97
Experienced flood in last 5 years	0.03	0.08	0.77	1.03	0.05	0.31	0.58	1.05	−0.10	0.40	0.53	0.91
Values and beliefs												
Climate change caused by nature	0.01	0.00	0.95	1.01	−0.12	0.36	0.55	0.89	−0.08	0.08	0.78	0.92
Uncertain climate change is happening	0.28	1.62	0.20	1.32	−0.06	0.09	0.77	0.94	0.07	0.06	0.80	1.08
Climate change human or human/nature	0.20	0.86	0.35	1.22	−0.12	0.36	0.55	0.89	0.06	0.04	0.84	1.06
Perception of risk scale (factor)	0.53	10.20	0.00	1.69	0.26	3.13	0.08	1.30	0.33	2.00	0.16	1.39
Practices used on owned land will be effective in future	0.16	1.19	0.28	1.17	0.03	0.04	0.83	1.03	0.03	0.03	0.87	1.03
Practices used on rented land will be effective in future	−0.04	0.07	0.79	0.96	0.07	0.32	0.57	1.08	−0.09	0.21	0.65	0.92
Have skills to manage farm in the future	−0.04	0.58	0.45	0.96	−0.05	0.88	0.35	0.95	−0.07	0.72	0.40	0.94
Farmer identities												
Productivist (factor)	−0.03	0.84	0.36	0.97	−0.06	3.46	0.06	0.94	−0.11	5.15	0.02	0.90
Conservationist (factor)	0.04	4.77	0.03	1.04	0.05	9.94	0.00	1.05	0.09	13.36	0.00	1.09
Controls												
Total Corn-Soy acres	0.00	1.37	0.24	1.00	0.00	43.11	0.00	1.00	0.00	9.46	0.00	1.00
Principal operator age	0.00	0.91	0.34	1.00	0.00	0.71	0.40	1.00	−0.02	7.39	0.01	0.98
Acres land owned	0.00	2.40	0.12	1.00	0.00	47.54	0.00	1.00	0.00	0.15	0.70	1.00
Acres land rented	0.00	0.40	0.53	1.00	0.00	11.85	0.00	1.00	0.00	4.15	0.04	1.00
Constant	−0.04	0.01	0.92	0.96	−0.04	0.01	0.92	0.96	1.46	6.03	0.01	4.29
2 Log likelihood	3002.41				3493.96				1794.95			
Cox & Snell R^2	0.035				0.052				0.500			
Nagelkerke R^2	0.051				0.069				0.096			

	Integrated Science Technologies Model 4				Water Control & Management Model 5			
	B	Wald	Sig.	Exp(B)	B	Wald	Sig.	Exp(B)
Biophysical situation								
Experienced drought in last 5 years	0.10	0.16	0.69	1.11	0.06	0.33	0.57	1.06
Experienced saturated soils in last 5 years	0.38	1.84	0.18	1.46	−0.43	13.20	0.00	0.65
River runs through land	−0.43	1.77	0.18	0.65	−0.45	13.58	0.00	0.64
Experienced flood in last 5 years	−0.51	4.08	0.04	0.60	0.44	16.90	0.00	1.56
Values and beliefs								
Climate change caused by nature	1.17	8.24	0.00	3.23	−0.19	0.72	0.40	0.83
Uncertain climate change is happening	1.06	6.27	0.01	2.88	−0.30	1.69	0.19	0.74
Climate change human or human/nature	0.87	5.08	0.02	2.38	−0.24	1.12	0.29	0.79
Perception of risk scale (factor)	−0.15	0.13	0.72	0.86	0.08	0.23	0.63	1.09
Practices used on owned land will be effective in future	−0.06	0.04	0.84	0.94	0.18	1.37	0.24	1.20
Practices used on rented land will be effective in future	0.27	0.73	0.39	1.31	0.06	0.16	0.69	1.06
Have skills to manage farm in the future	0.17	1.52	0.22	1.18	0.24	14.71	0.00	1.28
Farmer identities								
Productivist (factor)	−0.02	0.07	0.79	0.98	0.08	4.97	0.03	1.09
Conservationist (factor)	0.22	37.29	0.00	1.25	0.03	2.65	0.10	1.03
Controls								
Total corn-soy acres	0.00	7.53	0.01	1.00	0.00	1.48	0.22	1.00
Principal operator age	−0.02	2.88	0.09	0.98	−0.01	4.33	0.04	0.99
Acres land owned	0.00	0.63	0.43	1.00	0.00	31.25	0.00	1.00
Acres land rented	0.00	2.29	0.13	1.00	0.00	8.30	0.00	1.00
Constant	0.63	0.40	0.53	1.88	−2.33	23.58	0.00	0.10
2 Log likelihood	668.78				2703.95			
Cox & Snell R^2	0.031				0.061			
Nagelkerke R^2	0.123				0.092			

of drought conditions increases the likelihood of livelihood transformation (B = 0.32) as does the experience of flooding (B = 0.53). In terms of expansion, experience of drought increases expansion transformation (B = 0.24). This suggests partial support for the posited pulse-transformational adaption relationship. One or both of the farmer's identities are significant in

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Table 6
Transformational adaptations.

	Land Transformation Model 6				Livelihood Transformation Model 7				Expansion Transformation Model 8			
	B	Wald	Sig.	Exp (B)	B	Wald	Sig.	Exp (B)	B	Wald	Sig.	Exp (B)
Biophysical situation												
Experienced drought in last 5 years	0.04	0.15	0.70	1.04	0.32	4.49	0.03	1.38	0.24	5.69	0.02	1.27
Experienced saturated soils in last 5 years	0.06	0.22	0.64	1.07	−0.47	7.48	0.01	0.62	−0.25	4.41	0.04	0.78
River runs through land	0.41	8.24	0.00	1.51	−0.32	3.35	0.07	0.72	−0.03	0.04	0.84	0.98
Experienced flood in last 5 years	0.27	6.07	0.01	1.31	0.53	11.27	0.00	1.70	0.19	3.51	0.06	1.21
Values and beliefs												
Climate change caused by nature	0.19	0.51	0.47	1.21	−0.40	1.61	0.21	0.67	0.38	2.65	0.10	1.46
Uncertain climate change is happening	−0.03	0.02	0.90	0.97	−0.58	3.45	0.06	0.56	−0.05	0.05	0.83	0.95
Climate change human or human/nature	0.03	0.01	0.91	1.03	−0.30	0.98	0.32	0.74	0.12	0.28	0.60	1.13
Perception of risk scale (factor)	0.24	1.67	0.20	1.27	0.22	0.76	0.38	1.25	0.34	4.26	0.04	1.41
Practices used on owned land will be effective in future	0.12	0.59	0.44	1.13	0.17	0.80	0.37	1.19	0.30	4.40	0.04	1.35
Practices used on rented land will be effective in future	−0.14	0.83	0.36	0.87	−0.33	2.90	0.09	0.72	−0.28	3.81	0.05	0.76
Have skills to manage farm in the future	−0.07	1.25	0.26	0.93	−0.22	6.68	0.01	0.81	0.09	2.29	0.13	1.09
Farmer identities												
Productivist (factor)	−0.10	6.33	0.01	0.90	0.13	5.51	0.02	1.13	0.19	27.91	0.00	1.21
Conservationist (factor)	0.06	7.44	0.01	1.06	−0.06	4.94	0.03	0.94	0.00	0.05	0.83	1.00
Controls												
Total corn-soy acres	0.00	1.33	0.25	1.00	0.00	2.29	0.13	1.00	0.00	0.01	0.93	1.00
Principal operator age	0.00	0.06	0.80	1.00	0.01	2.98	0.08	1.01	−0.04	62.15	0.00	0.97
Acres land owned	0.00	9.63	0.00	1.00	0.00	2.65	0.10	1.00	0.00	13.16	0.00	1.00
Acres land rented	0.00	4.38	0.04	1.00	0.00	0.07	0.79	1.00	0.00	7.96	0.01	1.00
Constant	−2.37	20.74	0.00	0.09	−0.98	2.25	0.13	0.38	−0.37	0.64	0.42	0.69
2 Log likelihood	2504.33				1508.95				2910.33			
Cox & Snell R^2	0.026				0.024				0.075			
Nagelkerke R^2	0.041				0.053				0.107			

all models. The conservationist identity is likely to put in place incremental adaptions that address sloping lands (B = 0.04), and implement soil management (B = 0.05), grass waterways and buffers (B = 0.09), and integrated science technologies (B = 0.22). The more productivist the identity, the less likely a farmer is to employ land transformation (B = −0.10), but the productivist farmer is more likely to employ livelihood transformation (B = 0.13) and expansion transformation (B = 0.19). The conservationist results suggest that conservationists are more likely to consider land transformation (B = 0.06) but less likely to consider livelihood transformation (B = −0.06). Congruent with prior literatures (Prokopy et al., 2008), the demographic controls showed no consistent pattern across incremental or transformative adaptations. More detail about the effect of these variables on specific incremental and transformational adaptations are discussed below.

4.2. Incremental adaptations

All five of the incremental adaptation models (Models 1–5) offer support for the hypothesis that biophysical situations influence the degree to which farmers adopt incremental practices on their farms. Three of the five incremental adaption models (Table 5) involve making adjustments to the physical topography (Model 1, sloping land) or to better manage soil resources to limit erosion, protect, and/or build up the soil organic carbon levels (Models 2 and 3). Farmers experiencing drought are more likely to use sloping land management (B = 0.25) and soil management (B = 0.30), compared to farmers who have not experienced drought. Farmers who experience saturated soils are less likely to employ sloping land management strategies (B = −0.40), soil management (B = −0.23) and water control and management (B = -0.43) compared to farmers who do not experience saturated soil. However, farmers who experience saturated soil are more likely to adopt grass waterways and buffers (B = 0.28).

For farmers who have a river that runs through their lands, they are more likely to employ sloping land management strategies (B = 0.50) and more likely to use grass waterways and buffers (B = 1.09) compared to farmers who do not have rivers on their land. Farmers who have a river that runs through their lands are less likely to use water control and management strategies (B = −0.45) compared to farmers who do not have a river running through their land.

Last, looking at the experiencing of flooding, farmers who have experienced a flood in the last five years are less likely to use integrated science technologies (B = −0.51) but more likely to use water control and management (B = 0.44) than farmers who have not experienced flooding in the last five years.

Values and beliefs as potential inputs (climate beliefs, risk perceptions, confidence that current practices will continue to be effective in the future, and that they have the skills to manage the farm in the future) varied with the specific adaptation output. In soil management (Model 2) and grass waterways and buffers (Model 3) values and beliefs variables are not significant in predicting use of these adaptive management strategies. Climate beliefs are only significant in Model 4, integrated science technologies adaptation. The more a farmer believes that climate change is caused by nature the more likely he is to use integrated science technologies (B = 1.09) compared to those who do not believe that climate change is caused by nature. The more a farmer is uncertain that climate change is happening the more likely he is to use integrated science and technology (B = 1.06) compared to those farmers who are more certain. And the more a farmer believes that climate change is the result of human influence the more likely he is to use integrated science technology (B = 0.87) compared to those who are less sure that climate change is the result of human influence. In terms of perception of risk, risk is only significant in Model 1 with farmers who perceive more risk more likely to use sloping land management techniques (B = 0.53) compared to farmers who perceive less risk. Last, farmers who feel that they have the skills to manage their farms in the future is only significant in Model 5, with those more confident more likely to employ water control and management strategies (B = 0.24) compared to those with less confidence in the ability to manage their farms.

Farmers' identities also influenced decisions about incremental practices, although the data suggest that the effects of the conservationist are more consistent across practices. Productivist farmers are less likely to employ soil management (B = −0.06), grass waterways and buffers (B = −11) but more likely to employ water control and management (B = 0.08) compared to those with less productivist identities. The more a farmer holds a conservationist identity, the more likely he is to employ sloping land management strategies (B = 0.04), soil management (B = 0.05), grass waterways and buffers (B = 0.09), and integrated science technologies (B = 0.22) compared to farmers with less of a conservationist identity.

The R^2 for the incremental adaptation models ranged from 0.052 (Model 1), 0.069 (Model 2) to 0.092 (Model 5), 0.096 (Model 3), and 0.123 (Model 4). Control variables total corn-soybean acres, principal operator age, land owned and land rented varied in significance, across models, but all B coefficients, regardless of significance and direction were 0.0.

4.3. Transformative adaptations

Pulse-like events, significant drought and flooding, have the potential to activate farmer identities and as such can lead to different transformative adaptations. All three transformation adaptation models have biophysical situations and at least one values and beliefs variable that are significant (Table 6). The productivist identity is activated in all transformative models and the conservationist identity is activated in two models (land transformation and livelihood transformation). Similar to the incremental adaptation models, the control variables on corn-soybean acres, operator age, and land owned and rented varied in direction and significance but all B coefficients equaled 0.0. R^2 for the transformative adaptation models ranged from 0.041 (Model 1) and 0.053 (Model 2) to 0.107 (Model 3).

Model 6, land transformation, represents restoration and construction of wetlands and/or conversion of all or a portion of crop fields to grass and trees. Two biophysical situations, a river runs through my land and the experience of a significant flood in the last five years are significant and positive predictors of land transformation (B = 0.41 and B = 0.27, respectively). Belief and value items do not significantly predict land transformation strategies. Both the productivist (B = −10) and conservationist (B = 0.06) identities are significant but in opposite directions. The productivist identity is negatively associated with transforming the land to a use that would not produce a cash crop in the short term. Conversely, the conservationist identity is positively associated with conversion to grass or trees or wetlands congruent with valuing the land for more than short term profitability.

The livelihood transformation (Model 7) which includes selling or renting a part of the land, scaling back operations and/or quitting farming is predicted by two biophysical pulse events, experiencing a significant drought (B = 0.32) and significant flooding in the last five years (B = 0.53). This model is the only one of all eight models where the farmer experiences a double pulse event, that is, two biophysical conditions in the last five years that have potential to transform his livelihood. A third biophysical condition is a press, experience with saturated soils in the last 5 years (B = −0.47) which is significant but negative, meaning soils were not saturated. Values and beliefs item, "confidence I have the skills to manage the farm in the future" is negative and significant (B = −0.22). This suggests that farmers experiencing these extreme pulse events may have feelings of not being able to manage into the future (especially if both drought and flood events continue to occur) and thus may be more likely to choose a different livelihood. Both the productivist (B = 0.13) and conservationist identities (B = −0.06) are significantly related to the variable livelihood transformation. Farmers with a more productivist identity are more likely to indicate a livelihood change than are those with a lower productivist identity. These patterns suggest that the productivist may be more likely to perceive that farming will be less profitable in the future and therefore the best decision might be to make a major change in operations. Conversely, the conservationist farmer seems be less likely to sell or rent a portion of land or quit farming; suggesting that this farmer may assign other values to the land beyond crop production profitability. We are simply surmising this, of course, but it is consistent with the content of these previously established identities.

The last model, expansion transformation (Model 8) representing an intensification or expansion of current enterprises and/or diversification into other forms of production or different crops is a stronger model in terms of explained variance (R^2 = 0.107) than Model 6 or Model 7. The biophysical situations that are significant in this model are "experienced significant drought" (B = 0.24) and "experienced saturated soils" in the last five years (B = −0.25). Drought, a pulse event, is positive and the experience of saturated soils (a press) is negative, both of which reflect lack of water on the landscape. Examining the effects of values and beliefs, Table 6 (Model 8) reveals that risk perception (B = 0.34), "practices used on owned land will be effective in the future" (B = 0.30), and "practices used on rented land will be effective in the future"

(B = −0.28) are significant predictors of expansion transformation. The first two beliefs are positive. Perceptions of increased risk are interpreted as higher levels of concern about increased weed pressure, extreme rains, insect pressure, drought, plant disease, health stress, saturated soils, nutrient loss and soil erosion are more likely to result in the farmer expanding his operation. The second belief, the more a farmer believes that the farming practices used on his/her *own* lands will be effective into the future, the more the farmer is likely to engage in expansion of his operations. In contrast, the more a farmer believes practices used on *rented* lands will be not effective, the less the farmer is likely to engage in expansion of the operation. Expansion may be perceived by the farmer as giving him greater control over his operation if the land is owned rather than rented. In terms of identity, only the productivist identity is significant: the more a farmer has a productivist identity, the more likely the farmer will engage in expansion of his operations. This suggests that the productivist farmer is more interested in growing and expanding the farming operation compared to the conservationist farmer.

5. Discussion

Findings that farmer identities are significant in all models are consistent with other research in this area (McGuire et al., 2012, 2015; Zhang et al., 2016). The activated conservationist identity, consistent with meanings in that identity, is selecting adaptive management strategies that offer long term protection against soil erosion and nutrient losses from excess water and runoff. The activated productivist identity is less likely to put in place grass buffers for long term soil management or convert land to wetlands or non-crop uses. The productivist identity is more likely to utilize drainage and irrigation management to assure annual crop success and to expand the farming operation.

Results show that identities influence adaptive management decisions; and biophysical conditions, specifically pulse and press events, also are influences. There are various ways that farmers can adapt in relation to environment conditions and the type of biophysical situation (which we have termed pulse and press conditions) does influence the types of adaptive management that farmers employ. Values and beliefs, as independent predictors tend to be small and inconsistent suggesting that in the models presented here, identities and the biophysical situation are having the strongest effect on farmer's adaptive behaviors. To recap, farmers' productivist and conservationist identities influence the types of adaptive strategies that they employ on their farms. Further, results show that environmental conditions, in the form of pulse and press events, also shape farmer's choices about how to adapt their farming operations. Last there is little consistent evidence that farmers' beliefs and values play little, if any, role in terms of these decisions.

The models presented all assume simple direct effects. In presenting and discussing these results, there are numerous other questions that come to mind – namely, the different kinds of interactions that might be also important to examine in future research. For example, future research should examine how farmer identities' interact with changes in the biophysical situation. Productivists may respond very differently to a flood than would a conservationist. This could potentially be true for all biophysical scenarios presented here. Alternatively, one could consider simply the overarching type of event (pulse vs. press) and find more general patterns among identities. For example, the productivist identity may be more sensitive to pulse events than the conservationist identity. Based on the identity control model, it seems quite reasonable to expect that the interaction between farmer identities and types of events would then influence the type of strategies that are chosen. The conservationist who experiences a pulse event but has limited resources to "ride the tide" may strategize similarly to the productivist but for different reasons. Or, alternatively, pulse events may lead a productivist to "go for it" and up productivity efforts before things get worse. This as an important and pressing topic given how quickly the global climate is changing.

Only one or two of the values and belief items are significant in most models. Perception of risk is only significant in the context of incrementally managing sloping, hilly croplands. No-till adaptive management responses to significant drought may reflect perceptions (and scientific knowledge learned) that no-till can retain and increase soil organic carbon and hold soil moisture better than other tillage systems. All climate change views of causality are significant only in the integrated science technologies adaptation model. This may suggest that as science technologies are embraced, individual climate change beliefs may remain intact. This may prove to be another worthy avenue for future research. It is noteworthy that climate beliefs are not significant predictors of any other adaptive practices. Thus, even though farmers are experiencing and influenced by biophysical situations-drought, flooding, saturated soils—beliefs about climate causality are not explanatory factors in the selection of most practices. Although climate and agricultural scientists are conveying an urgency to adapt because of increasingly variable weather and climate, climate change beliefs seem not to be relevant to farmers in their management decisions. This is congruent with prior research on farmers which conclude that farmer adaptive and mitigative action may occur without engaging specific climate change causality beliefs (Arbuckle et al., 2015; Morton et al., 2015; Hyland et al., 2016).

The models' R^2, ranging from 0.04 to 0.123, explain a very small portion of the variance. Although the identity control theory offers valuable insights into how farmer's self-identities can influence adaptive management, it is important not to exaggerate the explanatory power of these models. While many qualitative and quantitative studies find that person identities, beliefs and values underlie complex social-ecological relationships, it has proven difficult to use these variables to statistically explain large portions of the variance. For example, Prokopy et al. (2008) meta analysis of 55 peer reviewed papers with statistical analyses of factors influencing BMP adoption find there are no factors that consistently determine BMP adoption. The farmer adoption of conservation practices literature similarly reflects low adjusted R^2 (Lockeretz, 1990). Lockeretz

(1990) observes that R^2 for these kind of studies typically are less than 0.25 and often well below 0.10 and illustrates this pattern in an examination of 16 published studies ranging from 5 to 20 explanatory variables. He finds that although beliefs and attitudes are frequently significant, when R^2 are the upper range, the model seems to be driven by the land's physical characteristics such as soil erodibility and slope. More recently, Zhang et al. (2016) ordered logit models for the implementation of three different nutrient management practices report R^2 ranging from 0.08 to 0.11. This suggests the relationship between the biophysical conditions and farmer traits continues to not be well understood. Much more work is need to untangle the complexities associated with different types of biophysical situations and their influence on values and beliefs which serve as input and have potential to move specific farmer identities to a higher place in the hierarchy of identities in support of the overarching sense of self, that I am a good farmer.

6. Conclusions

Pulse events such as floods are relatively discrete and can rapidly alter the agricultural landscape (Collins et al., 2011; Olson and Morton, 2012). Press events can accumulate and reach thresholds that also alter the agroecosystem (Morton and Rudel, 2014). Climate disruptions to agriculture have been increasing and are projected to become more severe over this century (Melillo et al., 2012) making the issues we have raised here even more important to understand. The US 3rd National Climate Assessment Report recognizes that agriculture has been able to adapt to recent changes in climate, but finds that the rate of adaptation needs to be accelerated to keep pace with the rate of climate change in the next 25 years (Melillo et al., 2012; Walthall et al., 2012). Further, current loss and degradation of critical soil and water assets due to increasing extremes in precipitation will require higher levels of innovation and adaptation in conservation methods than are currently in place (Walthall et al., 2012). Despite these concerns, farmer's beliefs about climate causality do not seem to be a motivating factor in farmer's adaptions. However, there is evidence that farmers are paying attention to the biophysical situation as well as being guided by their own understandings of themselves as good farmers.

Wolf et al. (2013) claims intentions to adapt arise when climate change is perceived as a process people can affect. Research needs to examine more thoroughly the way that adaptations occur when climate and weather conditions create a biophysical situation that activates farmer's identities. This is congruent with Adger et al. (2009) observation that underlying values and beliefs determine decisions about whether and how to adapt to climate change and that social and individual characteristics can act as limits to adaptation – and one might add that they may also facilitate those adaptations.

Despite the fact that this study found little evidence for the influence of values and beliefs on the adoption of particular practices, future research should examine how possible interactions among the environment, identities, and values and beliefs might encourage farming practices that protect and enhance the agroecosystem. The ongoing challenge is to accelerate learning and increase the type and range of adaptive management strategies farmers are willing to implement. Understanding what activates identities, core values and beliefs and how some values are privileged over others in adaptive decision making can help educators and policymakers to develop more effective interventions and policies. This suggests it is important to create learning situations and incentives that affirm and strengthen the conservationist identity which views that farmland needs managed and protected to ensure long term sustainability. Social science research has historically considered the environment as merely a backdrop for the functioning of social systems (Collins et al., 2011). This research begins to address this gap in knowledge by examining how the biophysical environment affects adaptive strategies. Future research should examine the multiple interactions among the biophysical environment and the people that inhabit them to better understand these complex relationships.

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